Studies of Polar Processes in the Lower Stratosphere Using UARS MLS Observations

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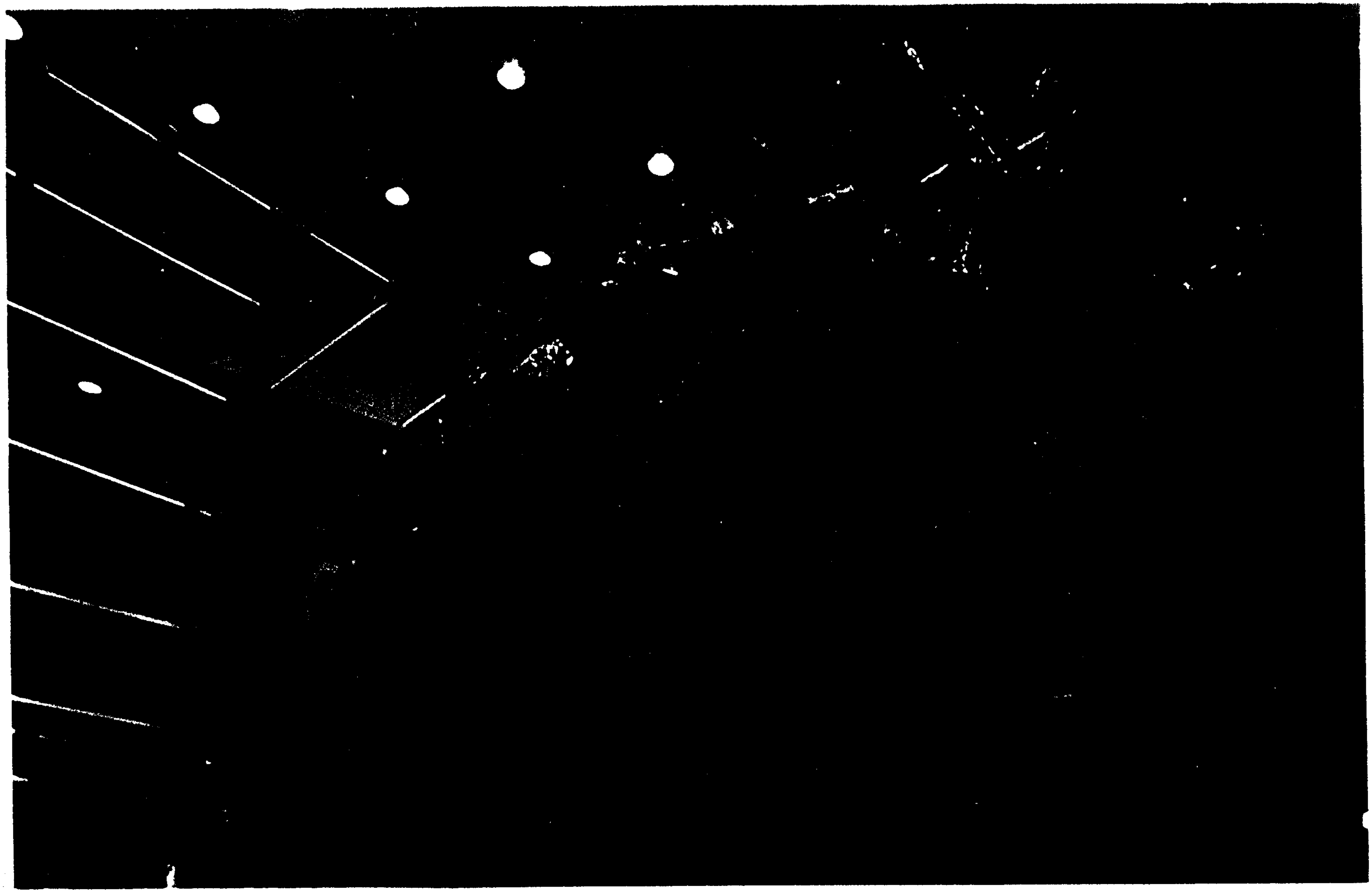
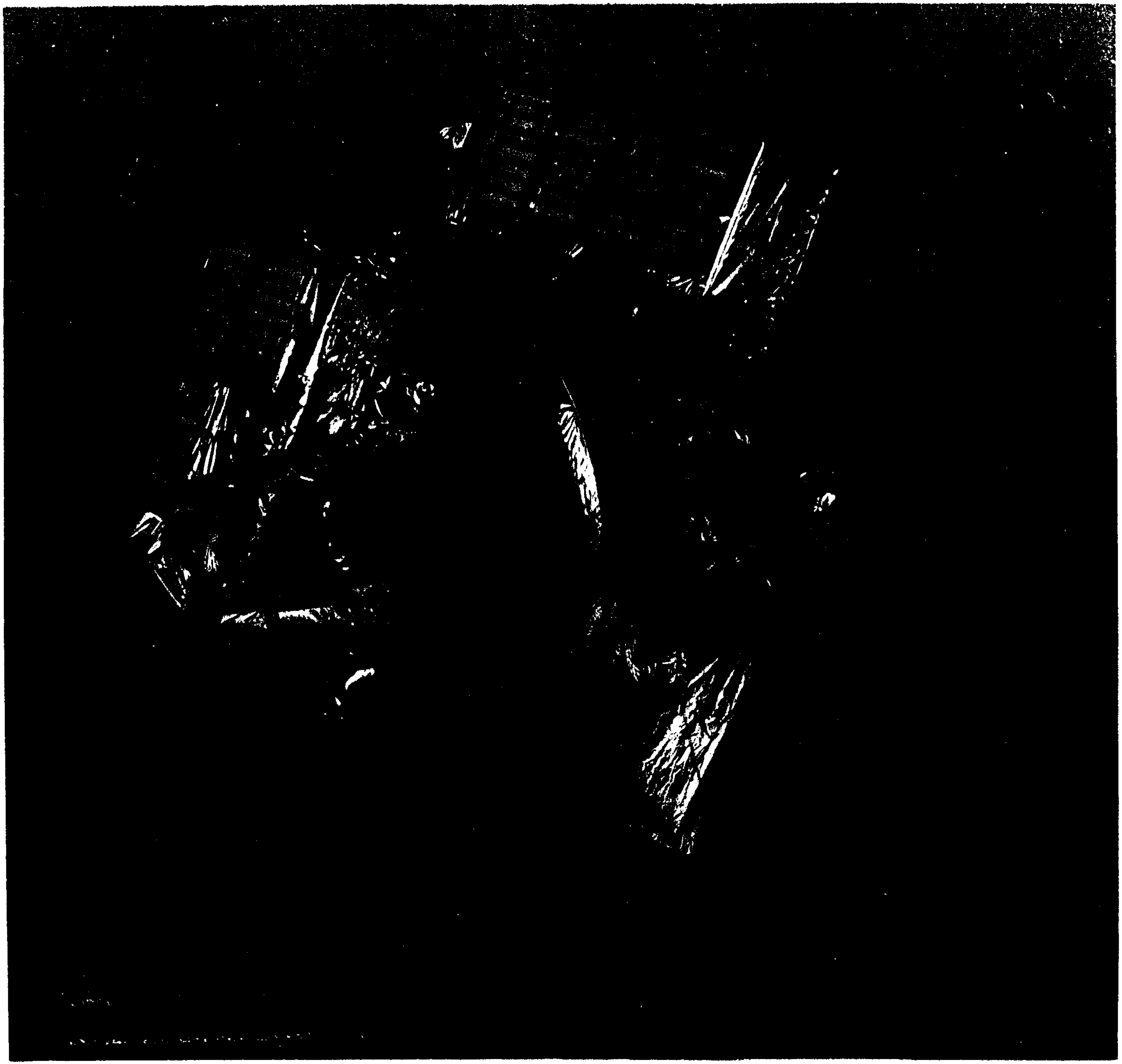


photo of UARS observatory in flight configuration - didn't reproduce well - sorry!



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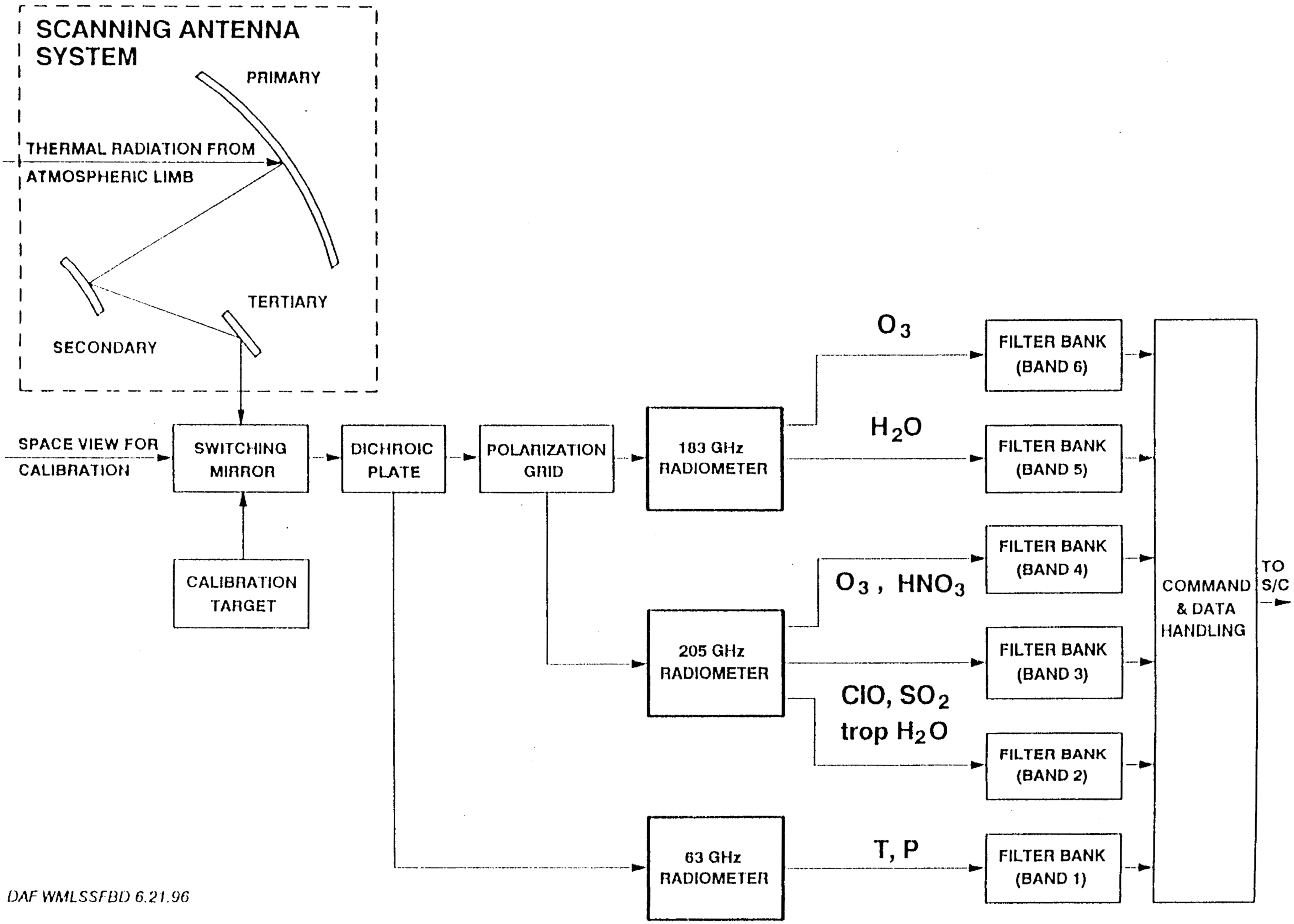
UARS MLS Data Coverage

- Latitudinal coverage of MLS measurements extends from 80° on one side of the equator to 34° on the other.
- All local solar times are sampled at all latitudes in a ~36 day period (a "UARS month"), getting about 20 minutes earlier each day at a given latitude.
- At the end of every UARS month, a 180° yaw maneuver is performed.
- Therefore, about 10 times per year MLS switches from viewing the high latitudes of one hemisphere to viewing the high latitudes of the opposite hemisphere.

⇨ MLS high-latitude data coverage is discontinuous.

UARS MLS SIGNAL FLOW BLOCK DIAGRAM



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Selected UARS MLS Results Related to Polar Processes in the Lower Stratosphere

Measurements from MLS and other UARS instruments confirmed the basic paradigm of stratospheric ozone destruction and clarified many of the processes involved.

- ✦ Chlorine was observed to be almost completely converted to chemically reactive forms throughout both the northern and southern winter polar vortices.

  e.g., Waters et al., Nature 362, 597–602, 1993

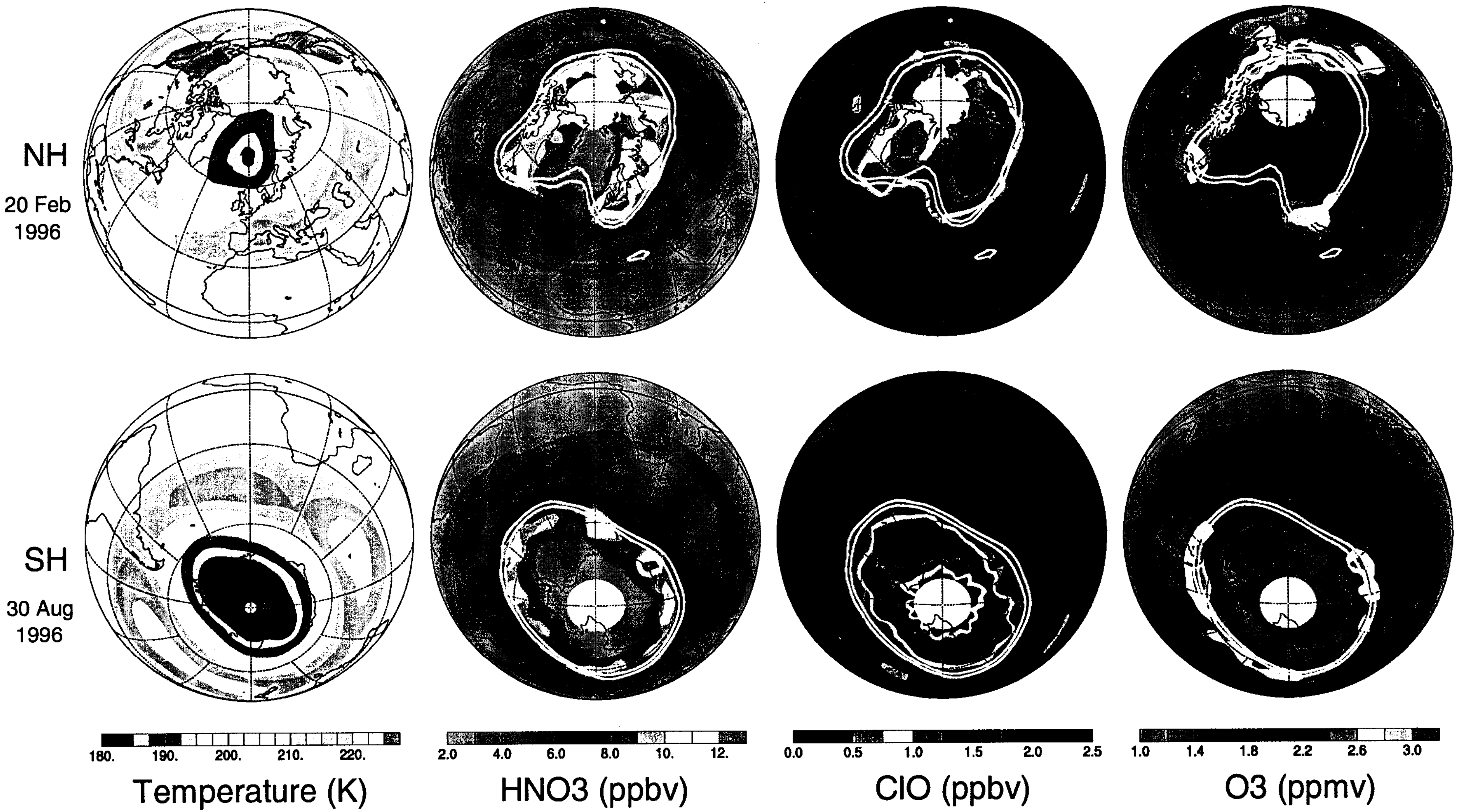
- ✦ UARS data, including MLS ClO, provided the first complete view of stratospheric chlorine partitioning.

  e.g., Douglass et al., JGR 100, 13,967–13,978, 1995
  Dessler et al., JGR 101, 12,515–12,521, 1996
  Chipperfield et al., JGR 101, 18,861–18,881, 1996
  Santee et al., JGR 101, 18,835–18,859, 1996

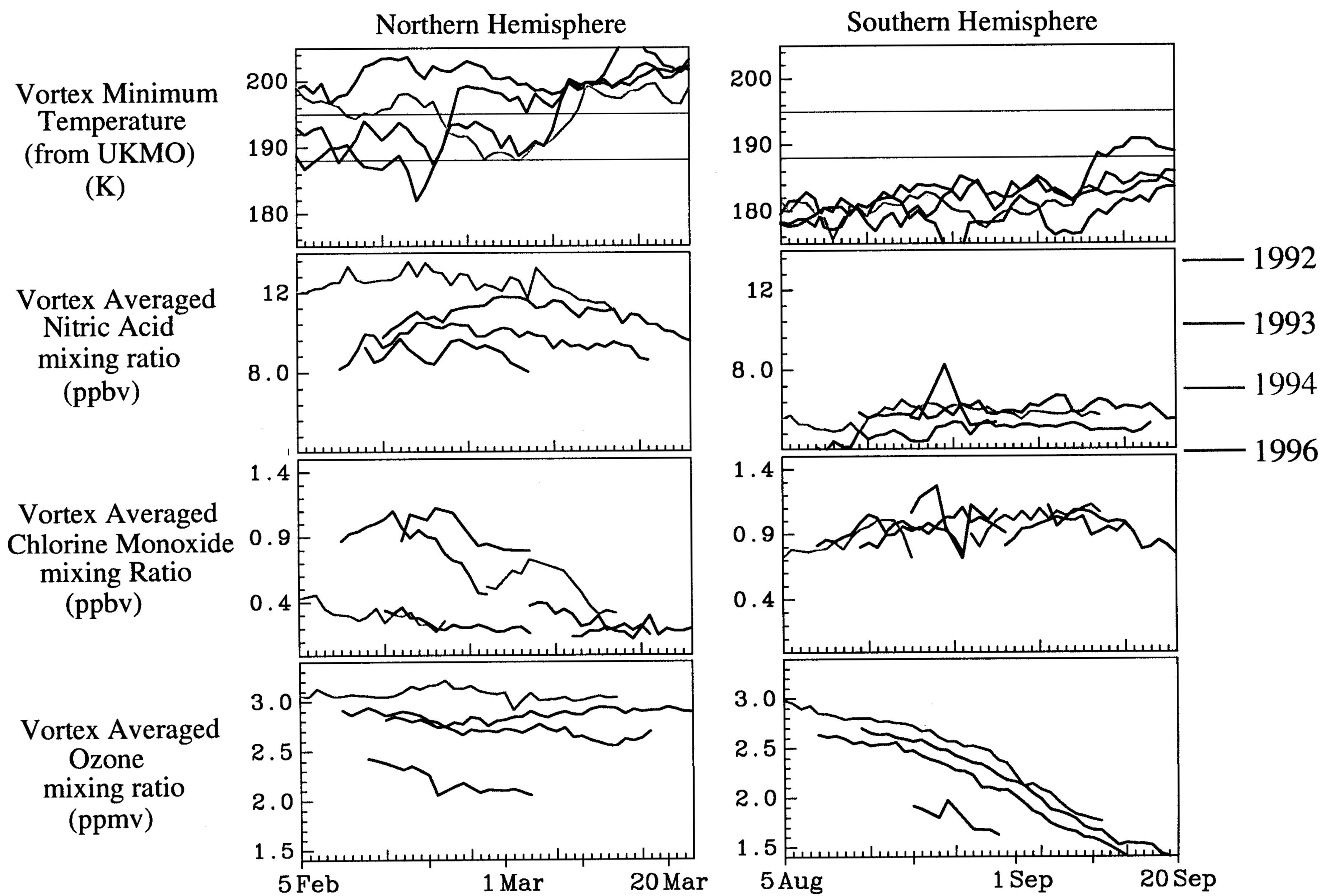
- ✦ Modelling studies using MLS and other UARS measurements reproduced the general features of polar processing and helped to quantify ozone loss.

  e.g., Douglass et al., GRL 20, 1271–1274, 1993
  Lefèvre et al., JGR 99, 8183–8195, 1994
  Geller et al., GRL 22, 2937–2940, 1995
  Yudin et al., JGR 102, 19,137–19,148, 1997
  Schoeberl et al., JGR 101, 20,909–20,924, 1996
  Lutman et al., JGR 102, 1479–1488, 1997
  MacKenzie et al., JGR 101, 14,505–14,518, 1996
  Manney et al., GRL 22, 2941–2944, 1995
  Manney et al., GRL 24, 2697–2700, 1997

UARS MLS Measurements in the Northern and Southern Winter Polar Regions



UARS MLS OBSERVATIONS IN THE ARCTIC AND ANTARCTIC LATE WINTER POLAR VORTICES



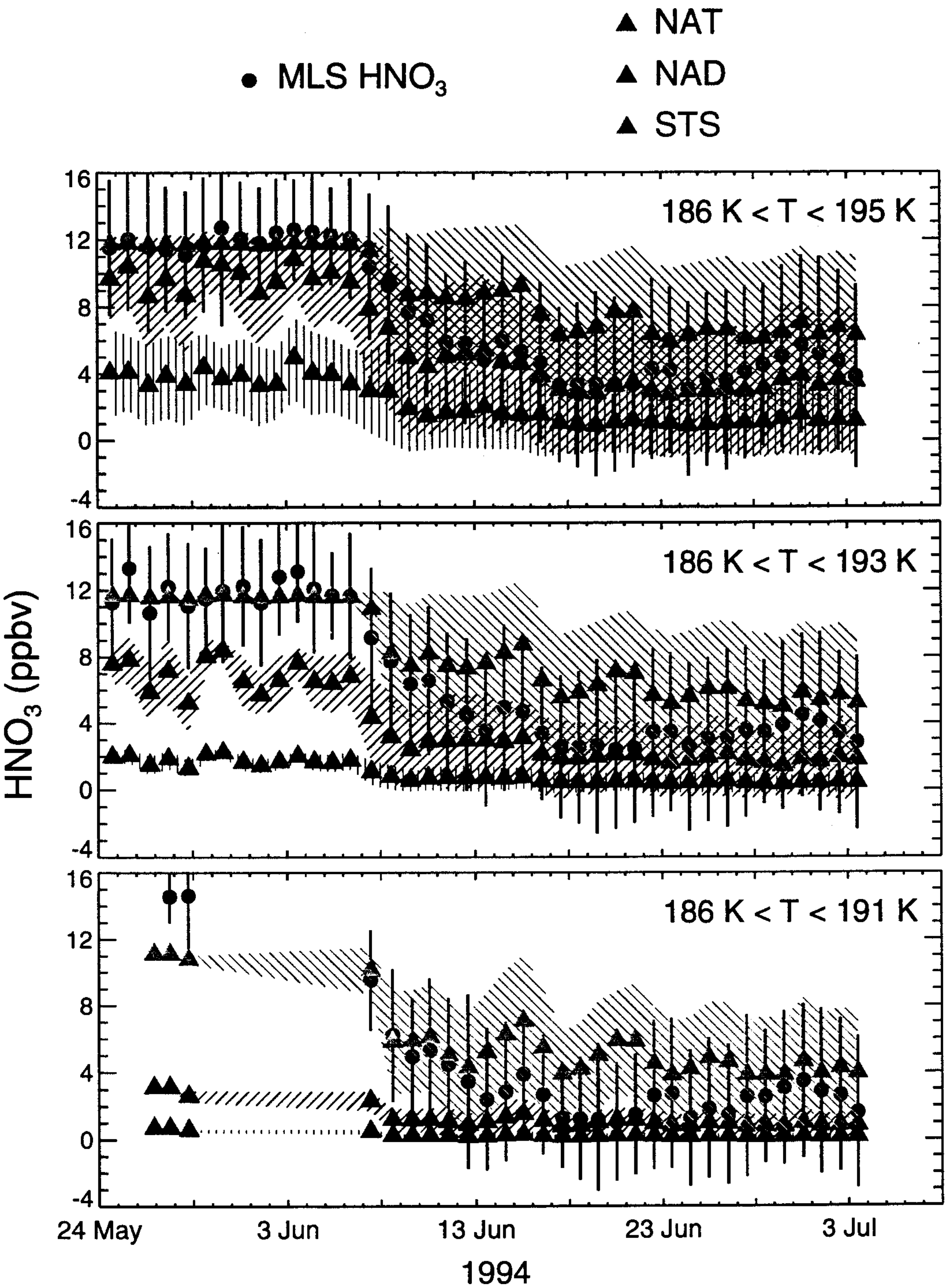
MLS HNO_3 Data in PSC Composition Studies

- ✦ Massie et al., GRL 24, 595–598, 1997
  - ✧ MLS, CLAES, ISAMS data from 9–10 January 1992
  - ⇨ Initial PSC growth processes are most consistent with the STS or NAD models.

- ✦ Dessler et al., JGR 104, 13,993–14,002, 1999
  - ✧ MLS and CLAES data from 1 SH and 4 NH winters
  - ⇨ Type I PSC formation in both hemispheres is best described by the STS model, although the NAD model cannot be ruled out.

- ✦ Santee et al., JGR 103, 13,285–13,313, 1998
  - ✧ MLS HNO_3 obtained at the beginning of 5 Antarctic winters: 1992–1996
  - ⇨ Although temperatures were low enough to support NAT PSCs, they were not forming (at least not initially).
  - ⇨ Formation of STS is initiated as temperatures drop below $\sim$192 K, followed by a gradual conversion to NAD after continuous exposure to low temperatures for several days.
  - ⇨ The much smaller degree of denitrification in the Arctic may be related not only to the lack of temperatures below the water ice frost point ($\sim$188 K), but also to the lack of temperatures persistently below $\sim$192 K.

Santee et al., JGR 103, 13,285-13,313, 1998

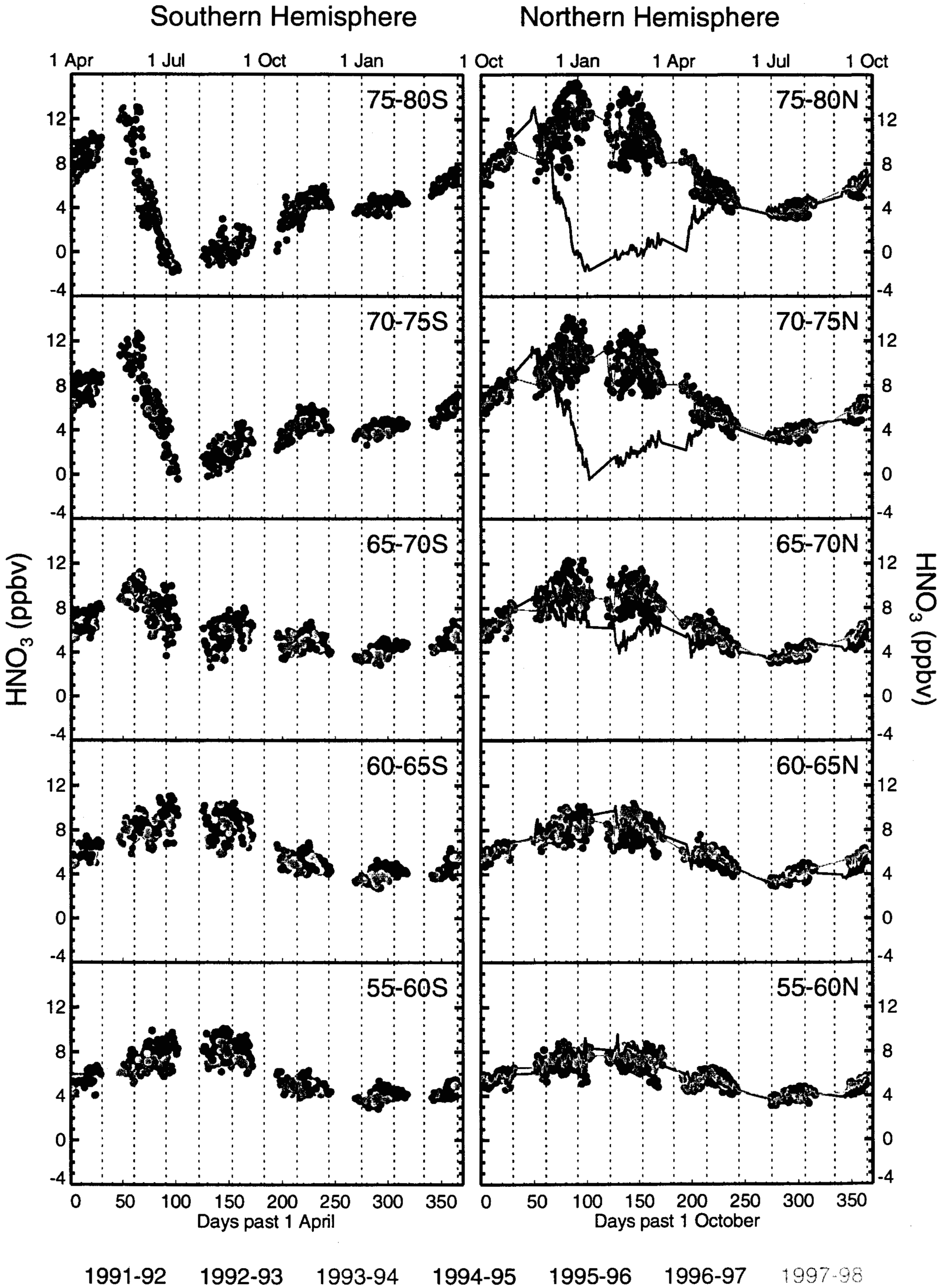


H_2O = 4.5 ppmv, total HNO_3 = 12 ppbv, sulfate mass = 0.3 $\mu g/m^3$

MLS HNO_3 Data in Denitrification Studies

- Santee et al., JGR 104, 8225–8246, 1999
  - MLS HNO_3 from six complete annual cycles in the lower stratosphere in both hemispheres
  - ⇨ Although the early-winter trends are similar, the HNO_3 behavior in the two hemispheres diverges as winter progresses, with large interhemispheric and interannual differences in the extent and duration of PSC activity and denitrification.
  - ⇨ Zonal-mean HNO_3 abundances at high latitudes recover to similar values at the end of every winter and in both hemispheres.
  - ⇨ Zonal-mean HNO_3 abundances at latitudes equatorward of 65° are virtually indistinguishable in the two hemispheres even during the winter months.
  - ⇨ The effects of severe denitrification are confined in both space and time to the regions poleward of 65°S during the winter and early spring.
  - ⇨ At least in a zonal-mean sense, denitrification does not have a strong influence on midlatitudes, nor does it have a long-term impact at high latitudes.

Santee et al., JGR 104, 8225-8246, 1999



EOS MLS

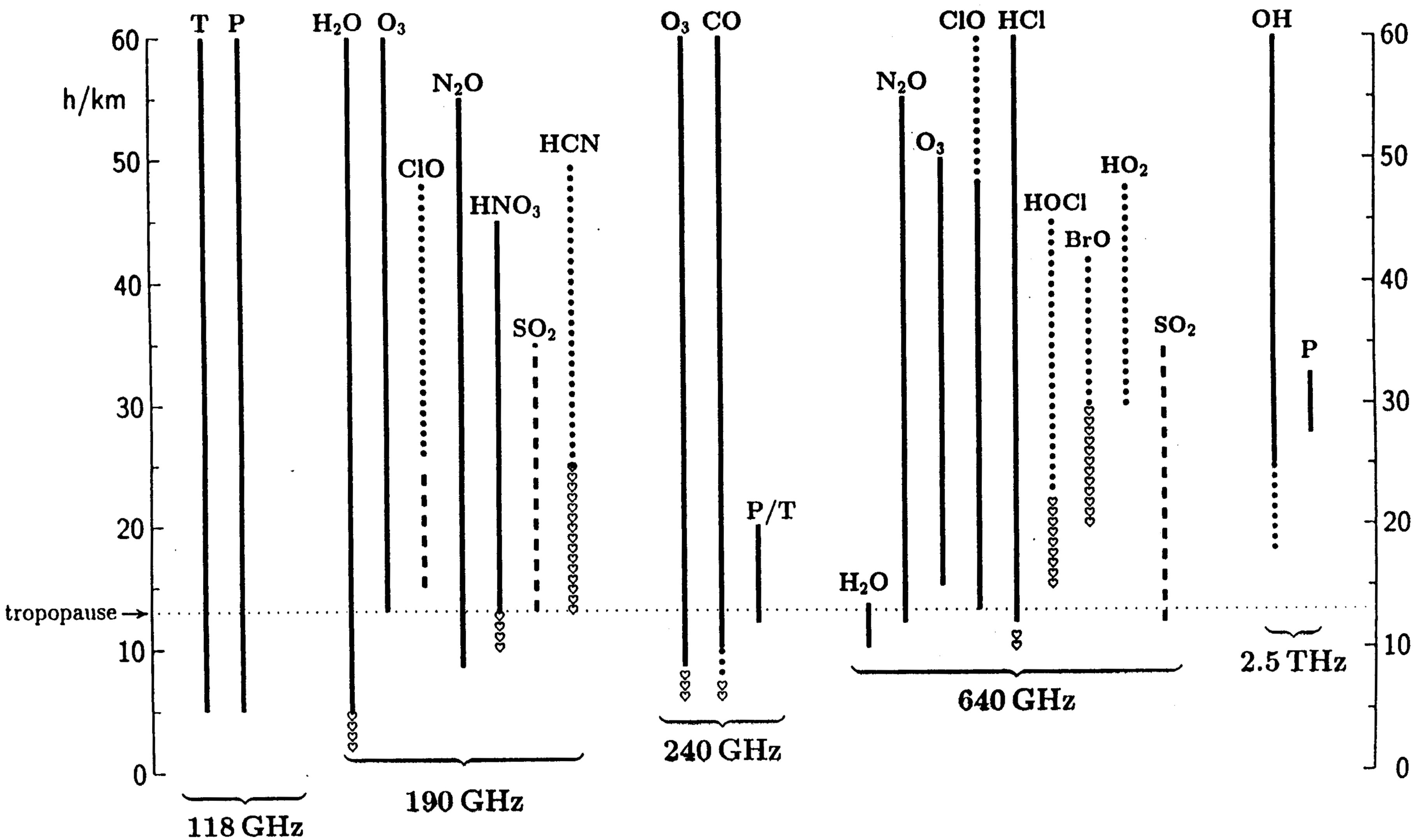
- Currently scheduled for launch on the NASA EOS CHEM satellite in December 2002.
- Improvements over UARS MLS relevant to studies of polar processes in the lower stratosphere include:
  - Better spatial resolution.
  - Better spatial coverage (82°N to 82°S on each orbit).
  - Better precision and extended vertical range for T, ClO and H_2O measurements.
  - Measurement of additional chemical constituents, e.g., HCl, HOCl, BrO, and the dynamical tracer N_2O.
- Expected vertical range for useful measurements and expected single-profile measurement precision at 20 km (from simulations for February 70°N by M.J. Filipiak):

Geophysical Parameter	Expected Range	Expected Precision
T	5–80 km	~1.0 K
ClO	15–40 km	~0.2 ppbv
H_2O	5–80 km	~0.2 ppmv
HNO_3	12–30 km	~3.0 ppbv
O_3	10–80 km	~0.03 ppmv
N2O	10–40 km	~30 ppbv
HCl	12–60 km	~0.2 ppbv
HOCl*	15–25 km	~0.01 ppbv
BrO*	15–45 km	~3.0 pptv

* monthly 5° zonal mean

EOS MLS Measurements — by radiometer

dotted are zonal means, dashed is volcanic SO_2 and enhanced ClO, hearts are goals
h>60 km is also sensed with alternative scan program
geopotential height is obtained from combination of 118 GHz and gyroscope measurements
cirrus ice content obtained from combination of measurements in 118, 190, 240, 640 GHz radiometers



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